ANALOG DEVICES

AN-308
APPLICATION NOTE

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Commutating Amp Multiplies Precisely

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By using a pulse-width-height modulation technique, the circuit in **Fig 1** implements a 0.015%-accurate multiplier. The circuit's output equals $V_X V_Y/10$. An AD581 voltage reference, an AD630 commutating amplifier, and an integrator comprising an AD707 op amp, 2000-pF capacitor, and 150-kΩ resistor first generate a precision triangle wave. For a given state of the AD630's output—$+V_{REF}$ at TP_1, for example—the integrator ramps until its output reaches $-11V$. Then, TP_1 changes state and the integrator begins ramping toward $+11V$. The triangle wave's period is 4.4RC or 1.32 msec, where R and C are the values of the integrator components.

The circuit uses a second AD630 driven by the variable V_X to compare the triangle waveform at TP_2 to the signal at V_Y. The duty cycle, T_1+T_2, at the output of this second commutating amplifier is as follows:

$$T_1 = 2RC(11 - V_Y)/10, \text{ and}$$

$$T_2 = 2RC(11 + V_Y)/10.$$

During T_1, the voltage at TP_4 equals $-1.1V_X$. During the remaining period, T_2, the pulse height will equal $+1.1V_X$. V_{OUT} is the average, obtained by lowpass filtering, of this T_1 and T_2 combined waveform and equals

$$V_O = \frac{-1.1\,V_X T_1 + 1.1 V_X T_2}{T_1 + T_2} = \frac{V_X V_Y}{10}.$$

You can use a higher bandwidth filter and a higher carrier frequency to build a faster multiplier.

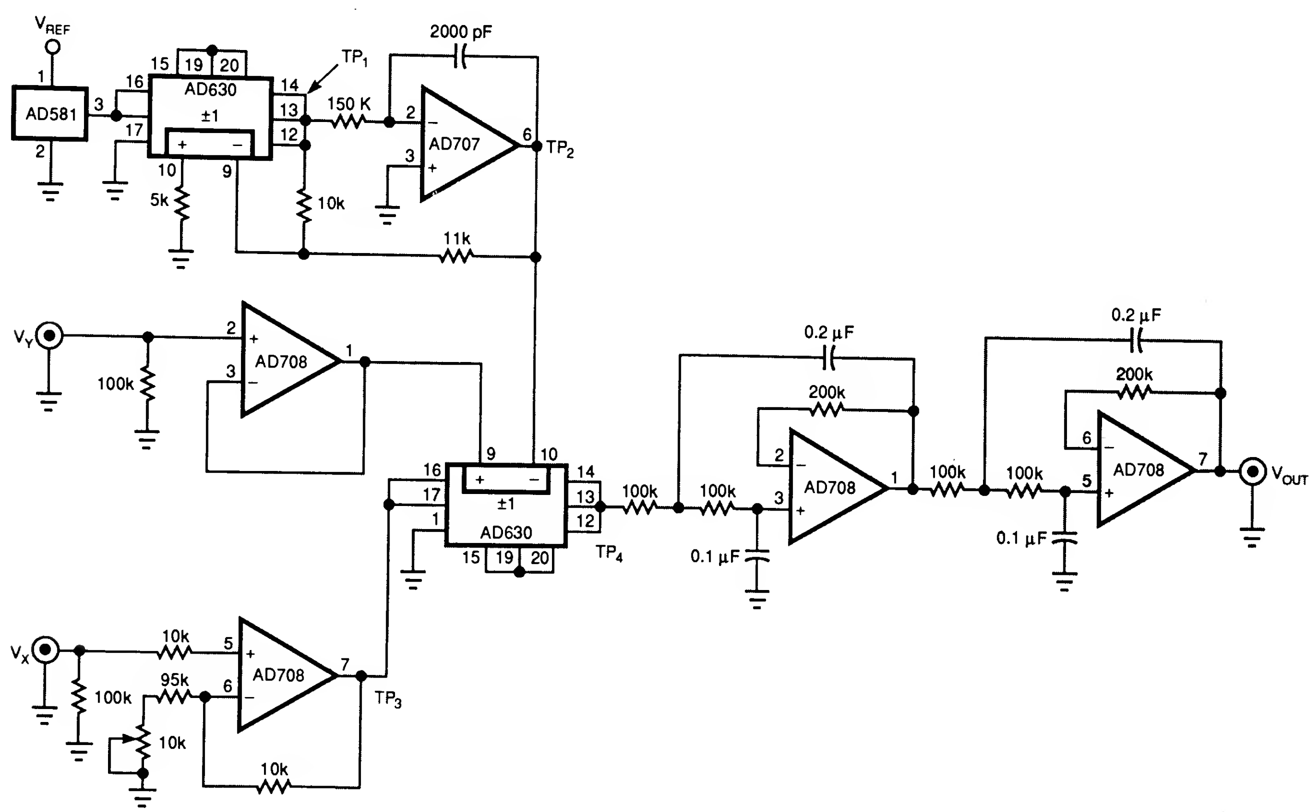

Fig 1—Two commutating amplifiers join a reference, an integrator, and a 4-pole filter to implement a 0.015%-accurate multiplier.

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